



State environmental action plan (SEAP), Gujarat – Energy sub- component

Summary report

Prepared for **Gujarat Ecology Commission**

April 2002

TERI Project Report No. 1999EM61

Table of contents

Energy and the environment	1
Energy demand	2
Energy supply	6
The environmental problems.....	11
The solutions.....	19
The action plan	31
The sustainable energy development program.....	35
 Annexure 1	 36-39

List of abbreviations

BCM	Billion cubic metres
BOD	Biological oxygen demand
BPC	Bharat Petroleum Corporation
CEA	Central Electricity Authority
CEPT	Centre for Environmental Planning and Technology
CNG	Compressed natural gas
CO	Carbon monoxide
CO ₂	Carbon di-oxide
COD	Chemical oxygen demand
CPWD	Central Public Works Department
CRE	Coal replacement equivalent
ERC	Electricity Regulatory Commission
ESCO	Energy supply company
ESP	Electro static precipitator
GEC	Gujarat Ecology Commission
GEDA	Gujarat Energy Development Agency
GMDC	Gujarat Mineral Development Corporation
gWh	Giga watt hour
HC	Hydrocarbons
HSD	High speed diesel
IIM	Indian Institute of Management
IOC	Indian Oil Corporation
IRMA	Institute of Rural Management, Anand
KW	Kilo watt
kWh	Kilo watt hour
LNG	Liquefied natural gas
LPG	Liquefied petroleum gas
mmbtu	Million british thermal units
MMCM	Million cubic metres
MMTPA	Million tonne per annum
MNC	Multi-National Corporation
MNES	Ministry of Non-Conventional Energy Sources
MoP&NG	Ministry of Petroleum & Natural Gas
MS	Motor spirit/ gasoline
MW	Mega watt
NGO	Non Government Organization

NID	National Institute of Design
NIOH	National Institute of Occupational Health
NO _x	Oxides of nitrogen
NSSO	National Sample Survey Organisation
NTPC	National Thermal Power Corporation
ONGC	Oil & Natural Gas Corporation
PUC	Pollution under control
PV	Photo voltaic
PWD	Public Works Department
RTO	Regional Transport Officer
SEB	State Electricity Board
SKO	Superior kerosene oil
SO ₂	Sulphur di-oxide
SO _x	Oxides of sulphur
SPM	Solid particulate matter
TEDDY	TERI energy directory data yearbook
TERI	Tata Energy Research Institute
TMT	Thousand metric tonne
TSP	Total solid particulates

Summary report

Energy and the environment

We use energy to cook our food, to light up our house, to water our crops, to travel, and so on. In most cases, the energy is supplied by a fuel such as wood or kerosene, which is burnt in a particular device. The environmental impacts of energy consumption depend primarily on the fuel used and the technology of converting the fuel into the desired form of energy, that is heat, light or motion.

The environmental impacts do not occur only at the point of consumption. Electricity used in the house is clean but the plant that is producing the electricity may be polluting the surrounding air. When thinking about the energy-environment interface, it is useful, therefore, to think of the entire energy chain covering the production, transportation and consumption of all the fuels in use.

The objective of studying the energy-environment interface is to reduce the harmful impacts to the desirable or at least, the feasible levels. Of the fossil fuels we use, coal and wood are highly polluting; oil is less polluting and natural gas is the cleanest. Renewable energy sources such as solar energy, photovoltaic cells, wind energy, hydroelectricity on a small scale, wave energy, etc. The use of renewable energy sources nearly eliminates the negative effects on the environment.

What is it that drives the transition to cleaner fuels and cleaner technologies and what is it that holds it up? By and large, cleaner fuels are costlier than the polluting fuels. If the environmental cost of using the dirty fuel is borne by the person who is making the choice, it is likely that he will be willing to pay more to use the cleaner fuel. This, of course, would happen only if he were aware of the environmental cost and if the difference in cost were reasonable. If the environmental cost is borne by someone else, it is likely that the dirtier fuel would continue to be chosen. The drive for cleaner fuels therefore requires generation of awareness, enforcement of the 'polluter pays' principle, the use of fiscal and other incentives to encourage the supply of clean fuels, strict norms to regulate emissions and research on renewable energy sources to bring down their cost. Much of this calls for public action, by governments and NGOs and much of it calls for freeing the markets in fuels and technologies.

In the 1970s, the Club of Rome published 'The Limits to Growth' in which it was predicted that the world would run out of oil in thirty years. The fears of running out of oil or the fears of an 'energy crisis' have now receded but sustainable use of energy has remained a concern. In these three decades, there has been a lot of research into the environmental problems of energy use, the role played by energy in economic growth and development and the social issues of unequal access to energy sources. A lot of experience has been gained in formulating and implementing the policies and strategies to solve these problems.

This report looks at these issues in the context of Gujarat.

Energy demand

Energy consumption in Gujarat shows a mix of the traditional and the modern. The share of various fuels in the final energy consumption is shown in the figure below.

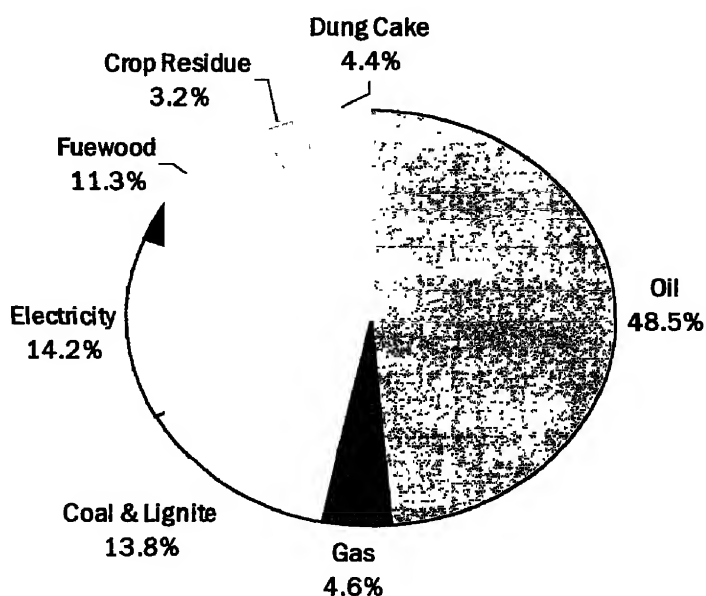


Figure 1 Final energy consumption in 1998/99

The per capita final energy consumption in Gujarat is nearly double the Indian average. The high level of energy consumption in the state has been the result of a number of factors. The rate of economic growth in the state since the 80's has been around 5.6%. Industrialisation and urbanisation has been faster than the rest of the country. The lack of surface water has forced a dependence on groundwater which has to be extracted using vast amounts of electricity.

Summary report

Energy and the environment

We use energy to cook our food, to light up our house, to water our crops, to travel, and so on. In most cases, the energy is supplied by a fuel such as wood or kerosene, which is burnt in a particular device. The environmental impacts of energy consumption depend primarily on the fuel used and the technology of converting the fuel into the desired form of energy, that is heat, light or motion.

The environmental impacts do not occur only at the point of consumption. Electricity used in the house is clean but the plant that is producing the electricity may be polluting the surrounding air. When thinking about the energy-environment interface, it is useful, therefore, to think of the entire energy chain covering the production, transportation and consumption of all the fuels in use.

The objective of studying the energy-environment interface is to reduce the harmful impacts to the desirable or at least, the feasible levels. Of the fossil fuels we use, coal and wood are highly polluting; oil is less polluting and natural gas is the cleanest. Renewable energy sources such as solar energy, photovoltaic cells, wind energy, hydroelectricity on a small scale, wave energy, etc. The use of renewable energy sources nearly eliminates the negative effects on the environment.

What is it that drives the transition to cleaner fuels and cleaner technologies and what is it that holds it up? By and large, cleaner fuels are costlier than the polluting fuels. If the environmental cost of using the dirty fuel is borne by the person who is making the choice, it is likely that he will be willing to pay more to use the cleaner fuel. This, of course, would happen only if he were aware of the environmental cost and if the difference in cost were reasonable. If the environmental cost is borne by someone else, it is likely that the dirtier fuel would continue to be chosen. The drive for cleaner fuels therefore requires generation of awareness, enforcement of the 'polluter pays' principle, the use of fiscal and other incentives to encourage the supply of clean fuels, strict norms to regulate emissions and research on renewable energy sources to bring down their cost. Much of this calls for public action, by governments and NGOs and much of it calls for freeing the markets in fuels and technologies.

The state has embarked on a growth path led by industrialisation. The energy consumption in the state will therefore continue to rise rapidly. For our purpose, we need to know how large the pie will grow and how the fuel shares will change. To understand this, we look at the important consumer sectors.

Industry

Gujarat has many energy intensive industries, such as, cement, paper, chemicals and petrochemicals, textiles, etc. The energy used in industrial units is required in furnaces and burners and to drive motors of various sizes. Coal, lignite and fuel oil are the main fuels used in furnaces and burners. However, LPG and natural gas have to be used in certain industries like glass where temperatures have to be accurately controlled. By far the most important energy source is electricity which drives the motors. Industry now uses around 43% of the electricity consumed in the state. Most process industries cannot afford disruption in electricity supply and have captive generators. Captive power generation amounts to as much as 20% of the electricity consumed in the state. These captive generators mostly use diesel but coal, naphtha and natural gas are also used.

How is this going to change over the years? The energy intensive industries are projected to grow at 6% annually. However, with technological improvements and changes in the composition of the sector, the overall energy intensity of industry is likely to come down. Studies conducted earlier have shown the scope of saving around 15% of the energy used by industry through conservation measures. However, the incentives for adopting such measures are weak. The most promising measure for reducing the net power consumption is the cogeneration of steam and power. Gujarat has a cogeneration potential of 416 MW in the sugar, paper, cement and chemical industries. A new policy announced by the state government has encouraged bagasse-based cogeneration in the sugar industry. Similar benefits need to be extended to other industries.

CEA projections show that electricity used in industry will grow at 7% in the next five years compared to 6% in the last five years. The regulatory reforms in the power sector will have a major impact in this area, but only on a longer term. Industry now subsidises all other power consumers. When tariffs are rationalised, the cost to industry would come down. This will encourage new investment and further industrial demand. For the same reason, captive generation which has been growing fast at 13% may slow down to around 3% annually. Natural gas, to the extent it is available, would be the preferred fuel for

captive generation. Imported LNG would also be preferable over coal, naphtha or diesel.

Coal and fuel oil will continue to be used for furnaces and burners because they are cheap. Natural gas from domestic sources can compete with these but LNG will not be competitive unless there is a large scale infusion of energy efficient technologies. This can be expected only if emission standards are made more stringent and are properly enforced.

Industry can use solar energy for low temperature process heat. However, the use of renewables at present is not appreciable.

Agriculture

Most agricultural operations are conducted even now using only human and animal labour. The two operations which use commercial energy on a large scale are ploughing and irrigation. Ploughing and tilling are done by tractors which use diesel while irrigation pumpsets run on diesel or electricity.

The distinctive feature of electricity use in irrigation is that the supply is not metered. The farmers do not pay for the energy consumed; they pay fixed charges depending on the capacity of the pump. The effective rate for power works out only to about twenty nine paise per unit. Such a low rate does not provide any incentive to optimise the use of energy. As a result, 28% of all the electricity consumed in the country goes into irrigation. For Gujarat, this percentage is 36%. Gujarat, like all other states, has a program for converting diesel pumps to electric pumps. The consumption of electricity for irrigation has increased at an annual rate of 5-6% and this growth rate is likely to continue.

The electricity sector regulator has taken up tariff rationalisation and has directed the electricity board to meter agricultural supplies. This is bound to affect the consumption pattern in the long run.

Solar power and wind can be used for running irrigation pumpsets, especially in remote areas where electricity is not supplied. Very few of these pumps are in use at present.

Transport

The transport sector is the fastest growing energy consumer, using mostly diesel and gasoline. In the nineties, the population of two wheelers, passenger cars, auto rickshaws and goods vehicles have all increased by 10%–12% annually.

The central government has recently allowed the use of LPG in this sector but it is not clear whether this would be a feasible alternative. The use of CNG as a vehicular fuel has caught on in Mumbai and Delhi. There is a possibility of using this fuel in Vadodara. However, CNG is viable only if a minimum

consumption is ensured and this requires concerted action by the government, the municipality and the gas suppliers.

Domestic

The domestic sector consumes 13% of the electricity consumed in the state. The bulk of this is consumed for lighting but other uses, such as, refrigeration, air conditioning, washing, entertainment and even internet connections are increasing fast. About 45% of the houses in the state do not have electricity. Kerosene is used in these for lighting.

Much of the energy required in the household is for cooking. In this, we see a steady progression towards cleaner fuels as the family income grows. The poorest use fuelwood, crop waste and cattle dung. The better off use biogas, kerosene or LPG. LPG was so far constrained by limited supplies. The situation has eased now. The state already has about 42 lakh LPG consumers. The number is likely to go up to 60 lakhs by 2011/12. Use of kerosene as a cooking fuel is limited to the urban areas. The use of kerosene will go down as more LPG becomes available. The state has an assessed potential of 5.5 lakh biogas plants and has already installed 3.5 lakh plants.

The domestic sector has been using renewable energies in the shape of solar cookers, lanterns and solar PV sets for quite sometime now. Solar cookers have not been popular as they do not suit the local food habits; the other devices are still too costly and have to be heavily subsidised.

Power generation

The power generation sector is also a consumer of various fuels. The per capita consumption of electricity in the state is 726 kWh compared to the national average of 399 kWh. The total installed capacity as in May 2001 was 8762 MW. The share of different fuels in the generating capacity is shown in the Figure below.

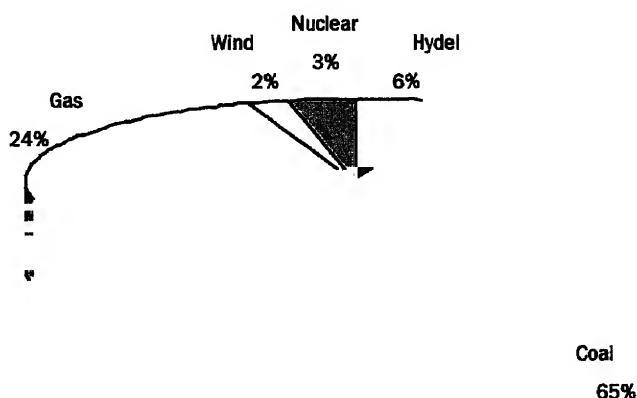


Figure 2 Fuel shares in power generation

It is interesting to note that the gas/naphtha based capacity in Gujarat has a share of 24% as against less than 9% at the all-India level. This is largely due to the availability of natural gas in the state.

CEA has projected the likely capacity addition upto the year 2011-12. These are shown in the Table below.

Table 1 Fuel-wise generation capacity addition (MW)

Fuel	9 th Plan (1999-2002)	10 th Plan (2002-2007)	11 th (2007-2012)
Hydro	60	104	1228
Coal	769	720	1220
Lignite	125	625	
Gas	298	1415	1270
Liquid Fuels/residue		500	
Nuclear	229		
Total	1481	3364	3718

Source. CEA

The above figures indicate that there will be a shift from domestic coal based power generation to cleaner gas based power generation in the coming years. This is based on the fact that LNG import facilities are planned at Hazira, Dahej and Pipavav.

The hydropower potential in the state is limited and very little is planned to be added to the installed capacity. The same holds true for nuclear power.

Gujarat showed early promise in tapping wind energy for power generation. 166 MW of capacity was set up in the state by 1996 but there has been no addition thereafter. GEDA is running a pilot project at Kothara for generating 500 KW from biomass. The viability of the project is yet to be established.

Energy supply

Having surveyed the scene from the demand side, we may examine the position from the supply side in terms of individual fuels.

Gujarat is rich in energy resources, as may be seen from the Table below.

Table 2 Energy resources of Gujarat

Source	Reserves	Remarks
Crude oil	148	Million tonnes - balance recoverable
Natural gas	84	BCM -balance recoverable
Coal	Nil	
Lignite	1505	(Million tonnes) Geological reserves
Hydel		

Source	Reserves	Remarks
Coal bed methane	1300	BCM – estimated resource
Wind power	4	Million gWh / year
Small hydro	156	MW
Biogas	5,54,000	Family type plants – ultimate potential
Tidal energy	900	MW – under consideration

Source. TEDDY 2001

Recently some gas fields have been discovered in offshore Gujarat. The chances of finding more oil and gas remain bright. The lignite reserves occur in Kachchh as well as Saurashtra. The exploitation of lignite could rise to around 20 million tonnes per year as against the present level of 6 million tonnes. The hydel resources in the state have by and large been exploited. The state is one of the leading states in India so far as wind power availability is concerned. The current exploitation is low compared to the availability of the resource. Tidal energy can be exploited in both the Gulf of Kachchh and the Gulf of Khambat. However, with the present state of the technology, the cost may be prohibitive.

Coal and lignite

Around 16 million tonnes of coal is consumed in the state annually, mostly for power generation. None of this coal is produced in the state. The coal comes mostly from Madhya Pradesh. In addition, about 3 million tonnes are imported.

Lignite is now produced at Panandhro in Kachchh and Mangrol in Surat. Pit-head power plants consume most of the lignite at both the mines. The rest of the lignite is used as industrial fuel.

Crude oil and petroleum products

Oil and gas production in Gujarat in the nineties have been as shown in the Table below.

Table 3 Crude oil and natural gas production in Gujarat

Production	1990/91	1995/96	1996/97	1997/98	1998/99
Crude oil (TMT)	6398	6362	6158	5951	5828
Natural gas (MMCM)	1696	2878	2932	3115	3166

Source. MoP&NG

In north Gujarat, the main producing fields are in Ahmedabad/ Mehsana. South Gujarat has the aged and declining Ankleswar field and the large Gandhar field. The entire crude oil produced in the state is piped to the refinery at Koyali for refining.

The Indian Oil Corporation's refinery at Koyali near Vadodara was commissioned in 1965 with a capacity of 3 MMTPA. The current capacity is 12.5 MMTPA and this is scheduled to be expanded to 19 MMTPA. Reliance Petroleum Ltd. has set up a refinery at Jamnagar with a capacity of 27 MMTPA. Essar Gujarat is also putting up a refinery at Vadinar with a capacity of 12 MMTPA.

Gujarat is one of the largest consumers of petroleum products in the country. The consumption of petroleum products in Gujarat over the last few years has been as shown in the Table below.

Table 4 Consumption of major petroleum products in Gujarat ('000 tons)

Product	1993/94	1994/95	1995/96	1996/97	1997/98
Naphtha	589	568	572	590	696
LPG	268	289	300	313	335
Motor spirit	311	327	393	415	443
Kerosene	790	806	813	828	858
Aviation fuel	35	43	47	67	59
High speed diesel	1772	2008	2403	2744	2951
Total	5966	6712	7695	8350	8671

Source. MoP&NG

The refinery at Koyali has been supplying most of these products. In future, some of these products will also be supplied by the two new refineries coming up in Gujarat. The Koyali Refinery acts as the nucleus for a number of industries, such as, IPCL and GSFC. The supplies to these units are made mostly through pipelines.

The requirements of consumers in the state are met through a network of marketing depots and retail outlets. There are over a thousand retail outlets selling MS and HSD and around 500 dealers in kerosene oil. The number of users of LPG in the state is around 42 lakhs. This may go up to 60 lakhs by 2011/12. The projected demand for MS, HSD and SKO in 2020 is shown in the Table below.

Table 5 Demand projections for petroleum products ('000 tonnes)

Product	Demand in 2020
MS	7128
HSD	13750
SKO	2616

Natural gas

Gujarat is the second most important gas producing region in India and production in 1998/99 represented 11.5% of the total indigenous production. The gas fields in north and south Gujarat are operated mainly by ONGC. Gujarat also receives gas from the western offshore fields. Most of the gas is used in power generation and production of urea. Gujarat also has city distribution grids in Vadodara, Surat and Ankleswar with around 1,50,000 domestic consumers.

The availability of gas from the fields of north and south Gujarat is projected to go down sharply. The likely increase in the availability from the western offshore fields will not fully compensate for the loss. The future of gas use in the state will depend on the import of gas. The prospects are bright as a number of LNG import projects are being pursued. Supplies could start by 2004 and a capacity for importing 10-15 million tonnes per annum of LNG by 2020 is on the cards. The power sector has to provide the anchor demand for the imported LNG. The industrial, commercial and residential sectors can provide some supplementary demand.

Renewables

Gujarat is a pioneer in the field of renewables. It was the first state to establish a state nodal agency, GEDA, for effective and systematic propagation of renewable energy in the state. Under the solar thermal extension program, solar cookers, solar dryers, solar stills, solar water heaters and solar timber-seasoning kilns have been promoted on a large scale.

Solar water heating has caught on. These systems are now in use in homes, hospitals, dairies, industries, guesthouses, hotels, canteens, temples, etc. Though the program started with a government subsidy, these heaters are now selling on their own. The dairies in Gujarat have played a major role in the solar energy program in the state. The solar cooker was the first renewable energy-based product promoted by GEDA. The local people have not accepted it as rotis cannot be made in this cooker.

A number of PV systems for domestic and street lights, fishing boat lights, water pumps and TVs have been installed all over the state, especially in tribal and remote areas.

166 MW of wind turbine capacity has been installed in the state. The initial success could not be maintained as the state government did not continue the incentives beyond 1997. Gujarat also has 200 irrigation pumps running on wind energy.

GEDA took up energy plantation in the wastelands of Kachchh in a major way in the 1980s. The program is multi-dimensional with linkages to energy supply, food and fodder, soil regeneration, ecological development and local employment generation. The species planted included the controversial *Prosopis juliflora*. GEDA's energy plantations in Kachchh cover 1450 hectares. A 500 KW pilot plant based on biomass is being run at Kothara.

A tidal power station is planned in the Gulf of Kachchh, having 36 units of 25 MW capacity each. There is considerable uncertainty over the likely cost of the project with cost estimates as high as Rs 8500 crores.

additional fuels

The percentage of rural and urban households in Gujarat depending primarily on biofuels for cooking is given in the Table below.

Table 6 Distribution of rural and urban household by primary source of biofuels for cooking (%)

	1989/90		1991		1993/94	
	Firewood and chips	Gobar gas / dungcake / charcoal	Fuelwood	Cowdung	Firewood and chips	Gobar gas / dungcake / charcoal
Rural	84.8	6.4	75.9	14.4	78.7	12.9
Urban	24.7	2.7	17.2	4.7	16.1	3.3

Source. TEDDY 1999-2000

In rural areas, this has remained steady at around 90% while in the urban areas it has come down to around 20%. As may be seen from Table below, fuelwood accounts for 36.5% of the total energy used by households.

Table 7 Percentage contribution of various fuels (compared in terms of CRE) towards household energy consumption

	Rural area		Urban area		
	Having no forests	Having forests	Urban centers having >0.1 M population	Urban centers having <0.1 M population	Total
Fuelwood	45.6	79.1	12.4	20.5	36.5
Agricultural waste	23.4	6.1	2.6	4.6	14.2
Dung cake	16.6	6.9	3.7	4.0	10.7
Charcoal	Neg.	0	0.4	0.1	0.1
Coke	0.2	0	17.5	19.3	7.4
Kerosene	12.3	7.0	22.7	23.6	16.2
LPG	0.6	0.9	40.7	27.0	14.1
Biogas	1.3	0	0	0.9	0.8

Source. Gujarat Wood Balance Study (1984)

With increasing family incomes, households would move towards cleaner commercial fuels for meeting domestic energy requirements. The Table below provides the estimates of fuel demands by consumer category for cooking.

Table 8 Fuel consumption for domestic cooking ('000 tonnes)

Fuel	Rural		Urban		Total	
	1995	2020	1995	2020	1995	2020
Firewood	10222	8820	1462	1019	11684	9839
Crop residue	2081	945	N A	N A	2081	945
Dung	2398	2011	555	232	2953	2243

The environmental problems

We have seen how energy is being used by the different categories of consumers in the state and the factors driving the choice of fuels. In looking for the problem areas, we start from energy production, look at energy transportation and finally, at the points of consumption.

Lignite mining

It is fortunate, in a way, that the state does not have coal mines. Mining of coal and its transportation can create severe problems as the examples of Bihar or Orissa show. Compared to that, lignite mining in Gujarat is very clean. The larger of the two mines worked by GMDC is at Panandhro, Kachchh. Due to the soft nature of the overburden, there is no need for blasting in this mine. Mining is continuous and highly mechanised in order that the growing production target can be met.

The overburden material produced is now dumped within the pit continuously. GMDC has recently taken up the monitoring of the environment in the mine area.

Kali and Korawadi are two streams passing through the mines. Opening up new areas for mining may involve the diversion of one of the streams. There is very little flow in the streams and such diversion would have limited effects.

Restoration of land within the mining area has been only partial and this is a matter that needs attention.

Oil and gas production

Oil and gas flow out through wells into pipelines and storage tanks from where they flow into other pipelines that take the oil to the refinery and the gas to fractionators or straight to the consumers. No environmental damage is expected unless there is a leakage somewhere. Such leakages are rare. A large

volume of water is produced along with oil. This is treated to a high degree of purity and re-injected into the oilfield. Wastewater produced in the treatment of crude oil is similarly disposed of.

Some amount of gas is unavoidably flared at the production wells. In theory, there is a possibility of damage due to the high temperature, SO_x, NO_x, hydrogen sulfide, etc. However, the gas has very little sulphur and no damage due to the other pollutants has been reported.

Drilling waste contains cuttings, chemicals, toxic organics and metal parts. These have to be disposed of without contaminating water bodies around the drilling sites.

Oil refining

Refineries produce gaseous emissions as well as solid and liquid wastes. These pollutants could be hazardous unless properly treated before discharge. However, highly sophisticated technologies are available to reduce pollution levels to well below the stringent standards applicable to refineries. Indian refineries have been protected by assured returns on investment through administered pricing of petroleum products and they have had little difficulty in installing state-of-the-art equipment for sulphur recovery, waste water treatment, etc.

The Koyali refinery is allowed SO₂ emissions of 1360 kg/hr. As against this, the actual emission is only 720 kg/hr at present. Emissions are continuously monitored through online computerised systems at three continuous ambient air monitoring stations. Wastewater from refineries typically contains oil, phenol, sulphides, suspended solids, BOD and COD. The refinery has reached the target of zero effluents in January 2000.

Solid and semi-solid wastes from refineries are hazardous in nature as these contain oil and other harmful chemicals. Oily sludge is formed in the crude and product storage tanks. This has to be disposed of in properly lined disposal sites so that groundwater is not affected through leaching. The groundwater quality around the refinery is regularly monitored to see the impact of solid waste disposal.

The new refinery at Jamnagar has similar facilities for control and disposal of pollutants. Since this refinery is designed to process imported high sulphur crude, sulphur recovery is done at various stages of the refining process. This refinery also has a coker, which can utilise oily sludge as input in making petroleum coke.

Power generation

The wastes generated by thermal power plants are typical of combustion processes. The exhaust gases from burning coal and oil contain particulates, SO_x, NO_x, CO₂, CO and volatile organic compounds.

Indian coals, in general, have low sulphur content and SO_x is not a problem unless the plant is of a large capacity. The sulphur concentration in the ambient air in the large coal fired plants in the state have at times exceeded the prescribed limits.

The lignite used for power generation has a high sulphur content. The plant at Mangrol, Surat uses the fluidised bed technology to tackle this problem. The older plant at Panandhro does not have any safeguard against sulphur.

Solid particles in the flue gas are trapped by ESPs. Often the ESPs do not perform to the required standards due to poor maintenance. The result is precipitation of ash in the surrounding areas. Such problems have been reported off and on in Ahmedabad and Gandhinagar.

Wastewater from power plants contain chemicals, oils and minerals which can contaminate water streams. The water is required to be treated before discharge. By and large, the plants in the state meet the prescribed norms for the discharged water.

By far the most serious problem is the disposal of fly-ash. In the first instance, the ash is dumped in ash-ponds as a slurry. When the pond fills up, the ash is transported in open trucks to landfill sites. This creates air pollution around the ponds, along the transport routes and near the landfills. Surface water is contaminated by ash-pond overflows. Even groundwater could be contaminated although there is no clear evidence of that happening.

Transportation of coal and lignite

Coal is transported both by road and by rail. Fugitive dust from trucks and coal wagons is a potential problem. However, there is no evidence of any serious damage on this account anywhere in the state.

Lignite is moved to pit-head power plants by conveyors. Lignite used by industry is moved by road. The trucks are quite effectively covered by tarpaulin and no significant dust emission takes place on the way.

Transport and storage of petroleum products

Pipeline transport of petroleum products is the safest although leakages do take place and pilferage could be dangerous. Movement by road or railway involves spillage and have to be tightly regulated. There are elaborate guidelines on

railway movement of products. These lay down the procedure to be adopted in handling each product depending on its characteristics. No major accident involving the railways has been reported. However, accidents on roads are fairly common.

Storage of petroleum involves loss of products through slow escape into the atmosphere. These losses can be reduced by using floating-roof storage tanks but then some leakage from the seals becomes unavoidable. In large tank farms near towns/cities this could have an impact on health. However, there is no evidence available on this point.

Dahej, Pipavav and Hazira are proposed to be developed to import LNG. The import terminals will have LNG storage and regasification facilities. Dahej proposes to have a storage of 150 thousand tonnes. Leakage of LNG would be extremely unlikely. No major accident has been reported in the 35 years history of the LNG industry.

Coastal and Marine pollution due to ship movement off the Gujarat coast could arise from tanker collisions or grounding, tank washing and deballasting. A number of instances of oil spills off Gujarat have been known. These include the accident involving the Cosmos Pioneer off Porbandar in 1973 in which 18000 tonnes of oil was released into the sea causing serious damage to marine animals. An oil spill was reported off Vadinar in November 2000 in which coral reefs and mangroves were damaged. Once the two coastal refineries reach their full capacities, crude import into Gujarat will increase sharply. Product import would, however, come down. Coastal movement of products within India would also increase. The number of tankers calling at Gujarat ports would increase.

This would go up further when new refineries planned in central India are set up. Oil spills affect marine animals and importantly in the Gujarat context, the coral reefs and mangroves. No studies have quantified the damage or related it to oil. However, in view of the expectation of increased tanker traffic in the area, this problem is potentially serious for Gujarat.

Urban transport

The number of registered vehicles in Gujarat has grown faster than the population or the growth in road infrastructure. The share of public transport in the vehicle composition has decreased from 5% in 1971 to less than 1% in 1997. Almost 93% of the total motor vehicles registered in Gujarat in 1995-96 were in the municipal corporations, suggesting that the major problems in the state due to automobile emissions were in the municipal areas. Of these, Ahmedabad, Surat and Vadodadra together accounted for 97% of the total vehicles registered.

The ambient air quality data for 1990-95 shows that SPM concentration has exceeded the national standard for residential areas in Ahmedabad, Vadodara, Surat and Rajkot.

A test of vehicular exhaust conducted by Consumer Education and Research Centre in Ahmedabad in 1993 on two wheelers, three wheelers and cars indicated that 65% of two wheelers, 55% of three wheelers & 70% of four wheelers had emissions above permissible standards for both CO and hydrocarbons.

Carbon monoxide, hydrocarbons and ozone are the major toxic elements in automobile exhaust. Carbon monoxide is a product of incomplete combustion of organic fuels. At sufficiently high concentrations, CO is fatal to humans. At the concentrations found in urban air, CO can aggravate cardiovascular diseases and may impair psychomotor functions. Scooters, motorcycles and autorickshaws, which have mostly two stroke engines, contribute nearly 79% of the total CO emission in Ahmedabad.

Hydrocarbons found in motor vehicle exhaust may not be directly harmful. However, they produce nitrogen dioxide and ozone, both of which are harmful at observed concentrations. Two stroke engines are the main producers of hydrocarbons.

Ozone is a strong pulmonary irritant that causes significant discomfort, respiratory illness and reduced pulmonary function in sensitive individuals. In addition, it is toxic to plants and damages many materials.

A major study by CEPT in 1995 concluded that emissions from mobile sources posed a major air quality and health hazard problem in Ahmedabad, especially in the old city areas and along major transportation routes. Drivers, passengers, traders and traffic policemen complained of giddiness, headache and nausea. The CO norms were exceeded in more than half of the 19 major traffic routes studied. The study estimated that nearly 21% of the city's population were exposed to emission levels with severe consequences.

Household energy use

Burning of biofuels in inefficient cook-stoves leads to high levels of indoor air pollution, causing eye and lung diseases. Though a large portion of time is spent outdoors in the rural areas, the indoor environment in these villages could be so polluted that they dominate the exposures of individuals who work in these environments.

The first field study of exposure was conducted in 1981 in Gujarat. This pilot study measured the exposure of cooks to TSP and CO in the cooking area. The

findings confirmed previous hypothetical calculations that village cooks are, indeed, exposed to high pollutant levels on a regular basis. Extremely high TSP exposures were found in the rainy season when all openings were kept blocked and ventilation was at the minimum.

Although hundreds of chemical agents have been identified in biofuel smoke, the four dominant ones are particulates, carbon monoxide, polycyclic organic matter and formaldehyde. These are known to cause acute respiratory infections, especially in children. Adverse pregnancy outcomes such as low weight at birth, chronic obstructive pulmonary disease, cancer, tuberculosis and blindness are the other problems associated with inhalation of this smoke.

Empirical studies on indoor air pollution have been conducted in Gujarat from 1981 onwards by NIOH and others. These studies have found very high levels of pollutants in indoor air at the time of cooking. Besides bringing out the differences between different fuels such as fuelwood, dung and crop waste, these studies have also estimated the improvements brought about by 'smokeless chulahs'.

Studies by NIOH and CEPT in Ahmedabad have found that 40% of the households used biofuels for cooking and that nearly 17% of the population was exposed to health risks due to indoor air pollution.

The adverse effects of traditional fuel use on human health are not restricted to problems of air pollution. Collection of fuels, besides being time consuming, exposes women to a variety of health risks.

Gujarat has a total forest area of 19,393 sq km constituting only 6.4 per cent of the geographical area of the State. It has only 0.03 hectare of forest area per capita against the national average of 0.7 hectares. The annual fuel wood availability from the forests of Gujarat is estimated at 438,000 cubic metres or 0.297 million tonnes. As against this, the total fuelwood requirement is 7.372 million tonnes. It is obvious that the use of fuelwood puts the meagre forest resources under great stress.

The use of kerosene for lighting also pollutes the indoor air. Although this is much smaller than the pollution caused by cooking fuels, it is an important problem in rural areas.

Groundwater depletion

Groundwater irrigation accounts for nearly 77% of the total irrigated area in Gujarat. One fifth of the districts are badly affected by groundwater depletion and another one-third are on the verge of being designated as 'dark' districts.

Many districts in northern Gujarat such as Mehsana, Banaskantha, Ahmedabad, Gandhinagar, Sabarkantha and parts of Saurashtra and Kachchh are regions with severe groundwater depletion. The annual rate of decline in water tables in these regions has increased from 1 metre per year in 1970 to 2 metres per year in 1998. In Kachchh, this decline has been more pronounced due to erratic and poor rainfall. In Mehsana, deeper aquifers are being used at 170% of their capacity.

Till 1960, tubewells were dug between 60-100 metres. Today they are bored in the range of 250-300 metres. In coastal areas, the decline in the water table has given rise to the problem of salinity ingress.

The increasing demand for irrigation and the receding groundwater level have resulted in an ever increasing demand for electricity.

The priority between problems

All the problems listed above are not equally important. In order to determine the priority among them, they have to be ranked according to some criteria that measure their importance. To do this, we look at the environmental, social and economic impacts of these problems. The points to be taken into account in evaluating these impacts are the following:

Economic impacts

- impact on income
- impact on public health
- size of population affected
- urgency of the problem

Social impacts

- impact on the poor
- impact on women and children
- impact on tribal people
- size of population affected
- urgency of the problem

Ecological impacts

- irreversibility or irreparability
- impact on critical ecosystems/species
- scale or scope of the ecosystem affected
- urgency of the problem

The major problem in this exercise is the inadequacy of data. Air pollution, for example, reduces the disposable income of families by increasing the medical expenses. However, no data on such linkages are available. Secondly, the division of the impacts into the three categories is artificial as these categories are not independent of each other. For instance, a damage to the forests would have an economic and especially a social impact. These limitations introduce subjectivity in the assessment. To reduce subjective bias, the marks were awarded after consultations with experts, facilitated by GEC.

The Table below shows the results of grading each impact on a scale of 1-10 with equal weights attached to ecological, social and economic impacts.

Table 9 Ranking of problems

Problem	Impacts				Rank
	Economic	Social	Ecological	Total	
1. Pollution from lignite mining	-	-	3	3	5
2. Pollution from oil & gas production	-	-	1	1	7
3. Pollution from oil refining	-	-	2	2	6
4. Pollution from fly ash	3	2	3	8	3
5. Pollution from transportation of coal & lignite	-	-	1	1	7
6. Pollution from transportation & storage of oil products	-	-	2	2	6
7. Automobile emissions in major cities	5	3	2	10	2
8. Indoor air pollution and pressure on forests	6	4	3	13	1
9. Overuse of ground water	3	2	2	7	4

The problem of indoor pollution gains importance because of the large number of people affected; 56% of households in the state use biofuels for cooking. Moreover, the problem affects poor people, women and children most. There is also the attendant depletion of forest resources in the state. The problem of fly-ash disposal is already serious. With a fourfold increase in power generation by 2020, this problem could affect many more areas in the state. Emission from automobiles is a serious problem in Ahmedabad and Vadodara. Safety problems in oil installations are manageable at present but will be important in future. More data would have to be collected in pinpointing the areas affected and the factors aggravating the threats to safety.

The following emerge as the three most important problems:

- Indoor air pollution
- Automobile emission in Ahmedabad and Vadodara
- Pollution from fly-ash

The subsequent sections of this report deal with the solutions to these problems. Besides, the problems standing in the way of greater utilisation of renewable energy for power generation is also examined. This is of relevance to Gujarat because of the large potential for using renewables and also the substantial experience gained in wind power.

The solutions

Policies and institutions

The problems that have been identified above have been known to be important for quite some time and the government has been taking steps to solve them. Then why is it that the problems persist? The answer to this question has to be found in the analysis of the policy instruments used by the government in solving the problems. The analysis must include not only the policies specifically focussed on the problems but the totality of policies impinging on them. It becomes necessary, therefore, to review the policies that have guided the overall development of the energy sector and have set the conditions within which individual policies had to operate. Specific policy measures are often designed to counter the unintended effects of previous policies. Their success depends on the strength of the constituencies pushing for them and the adequacy of the resources backing them up. Successful implementation requires that they rely on strong institutions or provide for capacity building in the institutions that they relied on.

Energy policy

Energy supply in India has been dominated by the public sector. Electricity is produced and supplied largely by the State Electricity Boards owned by the state governments. The coal industry was nationalised in the seventies and coal is now produced by Coal India Ltd. and other public undertakings. Oil and natural gas is also mostly in the public sector; the multinationals who ruled this sector after independence were replaced by public sector companies in the seventies. Oil refining by the private sector was allowed only in the nineties.

The ownership of these companies enabled the governments to control the energy prices. Without exception, the governments kept the prices low with a view to increasing access to these energy sources. This objective has been fulfilled to a large extent but the poorer sections, especially in the rural areas, continue to depend on traditional fuels like fuelwood and crop waste. These

non-commercial fuels account for about 30% of the total energy supply in the country.

On the other hand, subsidies and cross-subsidies have inhibited the development of adequate supplies and shortages have developed throughout the sector. The shortage in electricity and peak load has stayed around 20%. The shortage in good quality coal has required the import of non-cooking coal to the extent of around 30 million tonnes. Kerosene and LPG were in short supply till recently.

The subsidies often had unintended consequences. The subsidy on kerosene encouraged the adulteration of petrol and diesel by kerosene. The low price of electricity has discouraged investment in increasing the efficiency of electricity use. The policy of charging only a meter rent from agricultural consumers has led to overuse of groundwater for irrigation.

Since 1991, the government has opened up the energy sector to private investment. In electricity, private participation was first sought in power generation. This has not succeeded because the electricity boards are unable to pay for the power as they are not allowed to charge appropriate prices from their consumers. Efforts are now on to involve the private sector in transmission and distribution but not much progress has been made. In the oil sector, success in attracting MNCs into exploration has been modest. However, oil refining in the private sector has increased sharply. With the decontrol of petroleum prices in April 2002, the decks have been cleared for private retailing of petroleum products. The price of coal has been decontrolled but the program of attracting private investment in captive coal mining has not succeeded. The government is considering the opening up of coal mining to the private sector. An important change now taking root in the states is the installation of independent regulators to fix electricity tariffs, a job previously done by the governments.

The objective behind these sweeping policy changes introduced in the nineties was to facilitate private investment in the energy sector. The new policies were not directed towards the energy-environment interface. However, these have important implications for the environmental impact of energy use. Cost reflective prices could encourage conservation of energy and higher efficiency in energy use. The pollution control boards could be more free to take stringent measures against private power producers. Higher coal prices could encourage the use of gas for power generation. The SEBs could have an incentive in expanding power supply when they are able to recover their costs. The supply of LPG could expand once the subsidy is removed. At the same time, the increase

in energy prices could make it more difficult for poor people to use clean fuels. The net result would depend on how the total policy package works.

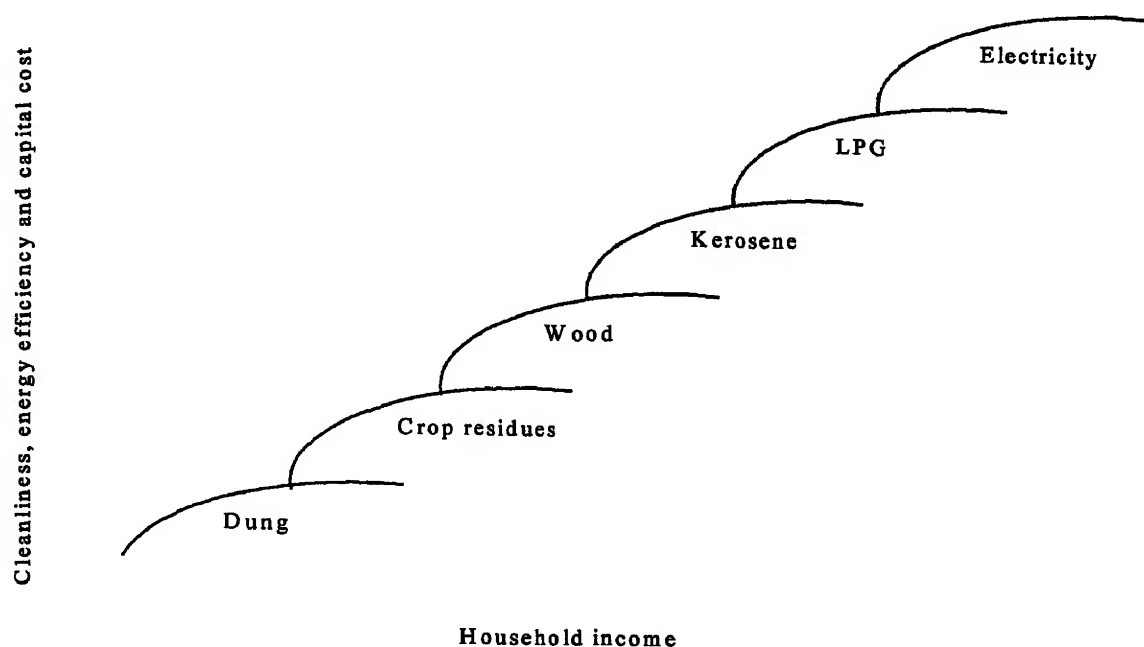
Once a competitive market in energy products and services is established, public policy may concern itself with laying down the norms for emission or fuel quality. The emission norms followed in our country in respect of coal based power plants or automobiles are behind standards achieved in the developed countries. The upgradation of standards is not a one time exercise. We have to build institutions that can pursue such goals continuously, through consultative and transparent procedures. The constituency for environmental improvement will grow wider as the costs of intervention are reduced. This will require research on the technologies of intervention. Additionally, the instruments of 'command and control' now in use in our country could be supplemented by market based instruments to optimise the cost-benefit ratio of such interventions.

To see how the institutional linkages affect the four identified problems, we examine them one by one, starting with the problem of indoor air pollution. The action plans adopted for these problems have to include policy initiatives to modify these linkages, where necessary.

Indoor air pollution

Indoor air pollution which is caused mainly due to cooking and partly due to lighting, can be reduced by using clean fuels and technologies. As family incomes rise, the chances of making this transition increases. Subject to the availability of alternatives, the transition could be from fuelwood to LPG or from fuelwood to kerosene and then to LPG, and so on.

The supply of LPG has so far been restricted because of constraints in production capacity and the capacity to import. The supply situation has now eased and the government has taken up a massive enrolment program. LPG would not be limited to towns with populations exceeding 20,000 and would be available in rural areas also. Private importers are allowed to import and sell LPG but the subsidised price of LPG has inhibited private imports. The subsidy is being progressively reduced.

Box 1. The energy ladder

As their incomes rise, families change over to cleaner fuels for cooking and lighting. The interesting questions are:

- Is there a threshold income for a particular fuel?
- What role is played by awareness of health impacts of indoor pollution?
- Which are the supply side features valued most by consumers?
- How to design an effective package of incentives? How to ensure that subsidies meant for the poor are not misused?

According to a recent estimate, LPG would cover around 50% of households in Gujarat by 2010 (in the business as usual scenario). It should be noted that this coverage will not be uniform over the state. While the coverage in highly urbanized districts will be 60%–80%, districts such as Banas Kantha, Sabar Kantha, Dangs and Panchmahals will be covered to the extent of 20%–30% only.

For those who are unable to make this transition and continue to depend on biofuels, the government has been implementing the Improved Chulahs Program. In Gujarat, the Panchayat Department is the nodal department for this program. The program is implemented mainly by NGOs and also by the panchayats.

12.5 lakh chulahs have been built in the state since the 80s. About 1 lakh new chulahs are installed every year. The chulahs, however, do not last beyond two years. The operative number of chulahs in the state should therefore be taken as two lakhs. The emphasis in the smokeless chulah program was placed on the efficiency of fuel use. The aspect of ventilation has been largely ignored. Ventilation continues to be poor in rural houses and in low-income urban households. The program has failed as a demonstration project to generate a demand for improved chulahs.

For the relatively better off, 325,000 biogas plants have been installed in the state, out of an assessed potential of 544,000.

GEDA has been distributing around 6000 solar cookers every year. The cost of these cookers is around Rs 1500 and the beneficiary has to bear Rs 700. One problem with the cooker now available in the market is that it is not suitable for frying or making *rotis*. The market is small on account of this limitation and the cost.

The villages in the state are mostly electrified and 77% of the households have electric connection. Solar lanterns and solar PV lights have been distributed, especially in the remote areas. Their acceptance has been limited on account of the high cost.

The critical institution here is the family which makes the fuel choices. The family income is widely recognised as an important factor in the choice of fuels. All policies aimed at enhancing incomes are, therefore, relevant to this problem. Many of these policies seek, in particular, to increase the income in the hands of women beneficiaries. These are especially relevant to our problem as women are more affected by indoor pollution than men. Apart from suffering from pollution, women using fuelwood spend a long time in collecting them. Policies that could link employment opportunities with the time saved by changing over from fuelwood could have a high degree of success in motivating a change to commercial fuels.

Incomes, however, change slowly. It is possible to change fuel choice faster by making cleaner fuels more easily available. The potential of such interventions can be gauged from the Table below:

Table 10 No per thousand of LPG consumers in different expenditure groups

India (1994-95)		
MPCE (Rs)	Rural	Urban
0 - 190	0	21
190 - 265	3	69
265 - 355	18	178

Source. NSSO

Although there are several factors at work here, these figures are strongly indicative of the impact of supply side factors on fuel choice. The experience of some states shows that availability of loans to cover the initial cost of getting an LPG cylinder can strongly encourage the shift to LPG.

Similar considerations apply to improved chulahs, solar lanterns/cookers and biogas plants. Ease of access, easy credit, repair facilities and a single window service can achieve a dramatic increase in the use of clean fuels.

The third factor that can be a strong influence is awareness of indoor air pollution as a problem, the awareness that medical expenses can be saved by changing to clean fuels.

A subsidy on the fuel or the technology cannot substitute for all these factors. A subsidy driven program implemented by governmental agencies will be limited by resource constraints and secondly, fail to generate a large response. What is required is that we promote private energy suppliers working at the micro level to provide these services. These ESCOs would not implement a particular program of a particular department but would take an integrated view of the energy needs of a household or a village. These ESCOs may be promoted by the government in partnership with the banks. These companies could operate in a cluster of villages with around 1000-3000 households to make the scale of operation viable.

Automobile emissions

Emissions from new vehicles can be controlled by laying down stricter emission norms. Emissions from vehicles in use, especially old vehicles have to be checked through better emission norms and more effective inspection procedures.

Emission of air pollutants from automobiles is regulated under the Motor Vehicles Act, 1988 which is a Central Act applicable all over India. Automobile emission standards, which were introduced in 1991, have been improved in 1993 and again in 1996. In 1995, the installation of catalytic converters in gasoline vehicles was made mandatory in metropolitan cities. This

has since been extended to 48 cities in the country. The norms for the year 2000 notified in 1997 required changes in the fuel injection system in passenger cars and catalytic converters in two stroke engines. For passenger cars, these standards are akin to Euro-I norms adopted in the European countries in 1992. For two/three wheelers, the norms enforced throughout the country from April 2000 are far stricter than Euro II norms and are one of the strictest in the world.

Improvements in the vehicular emission characteristics and in fuel quality have to move together as the full benefits of improved engines are available only if the fuel conforms to appropriate standards. In a competitive market it is enough to lay down the emission standards; refiners and auto manufacturers upgrade their facilities for fear of losing market share. In India, refineries are mostly in the public sector and there is little competition among them; the auto manufacturing industry has been competitive only recently. As a result, they have been able to resist changes in product quality.

The situation changed recently under pressure from NGOs and the courts. The Bharat Stage II norms have been introduced in the four metros. The Mashelkar Committee has recommended that they be extended to Bangalore, Hyderabad and Ahmedabad by 2003 and to the entire country by 2005. By 2005, Euro III equivalent norms have been recommended for these seven cities, except for 2/3 wheelers. Refineries will have to produce fuels of matching quality.

Box 2. Extracts from the draft recommendations of the Mashelkar Committee

- Bharat State-II norms which are in place in the four mega cities of Delhi, Mumbai, Kolkata & Chennai should be introduced in the other three mega cities of Bangalore, Hyderabad and Ahmedabad as early as possible but not later than the end of 2003.
- Bharat State-II norms should be introduced in the entire country from 1st April, 2005.
- Euro-III equivalent emission norms for all categories of vehicles (excluding two and three wheelers) should be extended to other parts of the country from 2010. The necessity and the feasibility of extending the the Euro-III equivalent emission norms prior to 2010 should be reviewed in the light of the experience gained after introduction of Bharat Stage-II norms in the entire country.
- To meet Bharat Stage-II and Euro-III equivalent vehicular emission norms, matching quality of petrol and diesel, detailed by the Committee, should be simultaneously made available.

Source. www.autofuelpolicy.org

If these recommendations are accepted, the emissions from new vehicles would be under control.

The emissions from 'in use' vehicles would still be a problem. In fact, this problem would increase as the higher prices of new vehicles would motivate owners to run their old vehicles longer. Under the Motor Vehicles Acts and Rules, all vehicles are checked for pollution every six months or earlier. This system has not worked satisfactorily for two important reasons. The PUC standards were set in 1991 and have not been revised. Secondly, the supervision over the certification has been poor in most cities and the certificates are available without any real testing.

The inspection system for private vehicles has to be overhauled. The Motor Vehicles Act has to be amended to provide for the following measures:

- Servicing of vehicles cannot be left to the will of the owners. All vehicles more than six years old should be compulsorily serviced thrice a year and vehicles more than nine years old should be serviced four times a year. The emission should be compulsorily checked at the time of servicing. The service stations should maintain computerised records of servicings and report non-compliance to the RTO.
- The service stations should be equipped to measure not only CO but HC and SPM also. They should have the responsibility to issue PUCs and should be free to charge fees determined by the market. They should be liable for penalties for negligence in performing their duties.
- Vehicle manufacturers should be liable to provide adequate servicing and testing facilities in major cities. Failing that, the RTO should have the powers to refuse registration of new vehicles.
- The government will have the responsibility and the powers to supervise the work of service stations and to cancel their license if necessary.
- The road tax rate may be kept low for the first six years and raised progressively thereafter.
- Penalties for violation of conditions should be effective.

The other measures that could be relevant are :

- Fiscal incentives for buying new cars.
- Supply of CNG and LPG wherever feasible
- Measures to check adulteration of fuels.

The last measure would call for not only better policing but removing price distortions of petroleum products that encourage adulteration.

These measures will no doubt increase the costs of motoring. This will be resisted by vehicle owners. Renewing the fleets of public buses frequently would

require that fares be raised frequently. This will also be resisted. The success of these measures would depend on the resources mobilised by the government and the NGOs to overcome such resistance.

Pollution from fly-ash

One way of avoiding the pollution associated with coal based power generation is by using alternatives like gas to generate power. At present, Gujarat has a generation capacity of 5648 MW based on coal and lignite. According to CEA's projections, this could go up to 6808 MW by 2012. Is it feasible to put up the additional capacity using gas instead of coal? It should be possible but this would probably involve the import of gas as LNG. Since the LNG chain requires large investments, such imports would be possible only if the financial health of GEB improves. This would in turn require the success of reforms started by the regulatory commission.

Box 3. Choice of fuel for power generation: coal or gas?

The rapid progress in the efficiency of gas turbines led to increased use of gas for power generation through the nineties. Combined cycle gas turbines with efficiency exceeding 60% have been designed. Turbines with 56% efficiency are commercially available. This can be compared with the efficiency of around 35% in conventional steam turbines.

The feasibility of gas use at a particular location is established by the 'imputed values' which measure the price of gas at which the cost of power equals the cost from an alternative fuel. For Gujarat, the alternatives are domestic and imported coal. Gujarat being far away from coal fields, the delivered cost of coal comes to Rs 1800-2000 per tonne. The price of imported coal varies; of late the cif price has stayed at \$35-40 per tonne. At these prices the imputed value of gas works out between \$4-5 per mmbtu.

Domestic gas produced by ONGC is now available at \$1.6-2.5 per mmbtu but the price is likely to go up. Gas from private fields is on offer at \$3.75 per mmbtu. Gas from LNG at the Gujarat coast could cost between \$3.5-4.5 per mmbtu at crude oil prices between \$18-25 per barrel.

This shows that gas based power could be cheaper than power from coal. GEB has an incentive to encourage gas based units even in the absence of an 'environmental premium' for gas as a clean fuel.

Source. TERI analysis

The problem of fly ash starts with the production of coal. The dominant policy objective of keeping the coal price low has encouraged open cast mining of coal where the overburden gets mixed with coal and increases its ash content to around 40%. Coal India had little incentive in improving the quality of coal as the price was administered till 2000. Besides, in the absence of competition, there is no threat to the market share because of the bad quality of coal.

For most power plants, the government has now stipulated that the ash content must be reduced to 34%. This would require either washing or blending with imported coal. The first option is not a good option for Indian coal. The latter option has been made more difficult by increasing the duty on coal, to protect the domestic industry.

The government has issued several orders to increase the utilisation of fly ash. All power plants are required to draw up plans for hundred percent utilisation of fly ash. Power plants have to make fly ash available to entrepreneurs free of cost. All brick makers located near power plants have to utilise at least 25% fly ash in their bricks. The Department of Science and Technology runs a Technology Mission for fly ash utilisation which has increased the utilisation to 13%.

Fly ash can be utilised in bulk in the construction of roads and embankments and in producing pozzollanic cement. In the seventies and the eighties, fly ash utilisation in cement making was encouraged by relaxing the standards for pozzollanic cement. This caused some mishaps which led CPWD and many state PWDs to ban fly ash use in public works. In the private market also, quality was as important as price and pozzollana cement lost out to portland cement.

Of late there has been some increase in the use of fly ash in cement production. Some cement plants are grading the fly ash before use, ensuring that quality is maintained. However, acceptability in the market is growing slowly.

Pollution from fly ash is a problem that cannot be solved by penal action. So long as there is a shortage of power, power plants cannot be shut down for violating fly ash disposal norms. It is difficult to enforce discipline in brick making as the sector is dominated by small operators. Cement plants, on the other hand are big and powerful. Success has, therefore, to be achieved through incentives. Fly ash is a valuable by-product of coal based power generation. Unfortunately, power plants do not have the competence to realise value out of it. Cement producers are well placed to utilise this material if marketing risks arising out of past mistakes are addressed and problems between cement plants

and power plants could be reduced. The government can play a major role in this, especially by using fly ash in public works.

Power from renewables

The government of India encourages investment in power generation from renewables through tax reliefs. Further, MNES has recommended that the SEBs should buy power from these sources at Rs 2.25 per unit escalated by 5% annually from 1994-95. The tariff in 2002-3 would come to Rs 3.32 per unit. The Gujarat government allowed the tariffs recommended by MNES till 1998. As a result, 166 MW of wind power capacity came up in the state. No new capacity has been set up thereafter as the tariff was discontinued. Even the installed capacity has not been fully utilised as the GEB increased the wheeling charges.

Although the objective of promoting power from renewables has not been abandoned, there has been no progress in the last five years for the following important reasons:

- Rural power consumers at the ends of long transmission and distribution feeders do not get reliable, good quality power. Distributed generation from renewables could improve the quality of power for these consumers. If these consumers were paying cost reflective prices for power, they could also experience a drop in the price of power. However, these consumers pay only a meter rent and are aware that improvements may be costly. The constituency for change is therefore weak.
- Generation, transmission and distribution of electricity in the state are highly integrated in the hands of the GEB. This means that the costs of these components are not transparent and the benefits of distributed generation are not obvious even to the state government or the GEB. The government meets the huge deficits run by GEB and is unwilling to increase the cost of power as it does not find it expedient to increase tariffs.
- GEB has no incentive in improving or expanding power supplies as it is not permitted by the government to increase the price of power. On the other hand, the transaction costs to GEB increase if power is to be purchased from small generators. In the case of wind power, there is the added disadvantage of variability in the output.
- GEDA has the mandate for promoting renewables and has taken up several research projects, including biomass gasification. GEDA has not built up a network of research institutions nor a network of NGOs for advocacy. Consequently, GEDA's influence on policy making has been weak.

- The Electricity Regulatory Commission which has the power to fix power tariffs has taken steps to rationalise power tariffs as also to reduce inefficiencies in the system. The Commission has adopted open, consultative procedures in arriving at decisions and has the opportunity of balancing the requirements of power consumers, GEB, NGOs and other stakeholders. This could provide the basis for bringing hidden costs into the open and facilitating a wide consensus on renewables.

Box 4. Current and potential future costs of renewable energy technologies

Technology	Turnkey investment costs (US \$ / kw)	Current energy cost (cents / kWh)	Potential future energy cost (cents / kWh)
Biomass electricity	900-3000	5-15	4-10
Wind electricity	1100-1700	5-13	3-10
Solar photovoltaic electricity	5000-10000	25-125	5 or 6-25
Solar thermal electricity	3000-4000	12-18	4-10
Hydroelectricity			
Large	1000-3500	2-8	2-8
Small	1200-3000	4-10	3-10
Geothermal electricity	800-3000	2-10	1 or 2-8
Marine energy			
Tidal	1700-2500	8-15	8-15
Wave	1500-3000	8-20	Unclear
Current	2000-3000	8-15	5-7
OTEC	Unclear	Unclear	Unclear

Source. WEA 2000; UNDP, UNDEAS, and WEC

The conclusion that we draw from this analysis is that GEDA, which has the mandate to promote renewables and has pioneered work in this area, can be given a central role in promoting renewables for power generation provided that it is suitably strengthened. GEB is a strong body which is opposed to increasing generation based on renewables. GEB has to be won over by redesigning policy instruments so as to address the concerns of GEB also. GEDA will have a better chance of success with the ERC fixing power tariffs through an open and consultative process. A part of GEDA's strength could come from linkages with NGOs and research institutes. These linkages would have to be built. A strong research input is required to identify the benefits from distributed generation using renewable sources and in solving problems of variability in power output from wind turbines.

The action plan

The foregoing analysis shows that the physical actions to be taken in solving the problems have to be accompanied by policies and institutional support. The action plan has to bring together the institutional and the physical actions as packages for each problem, as indicated below.

Indoor air pollution

The solution to the problem lies in increasing the use of LPG, biogas, improved chulahs, solar cookers and electric lights including solar PV based lights/lanterns. The key missing element in the way government programs have been implemented so far has been the element of marketing. It is proposed to supply this element by forming ESCOs and empowering them to supply these goods and services. The ESCOs have to be supported by soft loans for which schemes need to be drawn up with the banks. Technical and managerial support would also have to be organised in the beginning. IRMA and IIM could help in this. An attempt should be made to involve the large energy companies in the state like IOC, BPC, Reliance, etc in supporting these ESCOs. To generate a sense of competition, these companies could be encouraged to adopt separate districts for intensive coverage. The program could be launched in three districts to begin with. These companies have the capacity to sustain the ESCOs in the face of teething troubles. The companies would be rewarded by entry into the rural markets. In the long run, the experience with renewable energy would be valuable to them. Some of the leading oil sector MNCs in the world have announced that 50% of their revenues would come from renewables by 2050. Their Indian counterparts may need only a push to get started.

The success of these ESCOs in the initial years would depend on close nursing by the government. GEDA is best placed to act as the nodal agency in this respect.

The ESCOs will organise awareness campaigns in their areas. In areas not covered by these ESCOs, GEDA has to continue and step up its ongoing programs. An awareness generation program should be launched in these areas with the help of government departments and professional agencies. The campaign could be co-ordinated by GEC.

Formation of ESCOs and the strengthening of GEDA are the crucial capacity building measures required for this action plan. GEDA should not limit its activities to renewable energy only and should look at energy as a whole. It should be headed by a senior official and invested with a sizeable budget which allows it to carry out the research work needed in this field. GEDA should not

utilise NGOs only for implementing its programs but should encourage the NGOs to think about energy issues and build a support base in them. GEDA should avoid growing large by outsourcing routine work.

The subsidy on LPG and kerosene is being phased out. To compensate for the higher price of kerosene, the electrification of rural households has to be accelerated. A subsidy for domestic electric connections could be considered as it will not have the bad effects of the subsidy on kerosene. A soft loan or subsidy to meet the initial cost of the LPG connection should be made available. The subsidies on solar cookers/lanterns, etc will need to be continued. These should be restructured after learning from the experience of the ESCOs.

Indicative numbers for the physical targets to be achieved by the ESCOs and GEDA are worked out below. Assuming that 60 lakh households would be covered by LPG in the normal course, another 20 lakhs should be targeted through better services and soft loans/subsidy for LPG connections. This would still leave 40 lakh households not covered. The improved chulahs program has to be stepped up to 10 lakh houses per year so that 20 lakh houses are covered at any time. The present deficit of 2 lakh biogas plants should be filled and the potential should be reassessed. 50 thousand new houses should be supplied electricity every year. Upto 1 lakh solar cookers and 10 thousand solar lanterns/solar PV lights should be sold annually.

Planting of trees for fuelwood has to be encouraged by making non-forest and possibly forest land available for plantation.

Research work on indoor air pollution has centered around measurement of pollution levels and evaluation of improved chulahs. What is required is that we develop models of decision making at the family level and evaluate health impacts and medical costs. Only such detailed studies can help in justifying the required expenditure and coming up with effective incentives.

Designing improved solar cookers to suit the local food habits is also a priority research problem.

Automobile emissions

The size of the automobile market and the petroleum products market in India is limited and it is not feasible for the states to pursue their own programs for upgrading these. The Motor Vehicles Act also puts this responsibility on the central government. It is expected that the program for the next few years will be finalised by the central government soon.

The inspection procedures are the joint responsibility of the central and the state governments. It is open for a state government to tighten up the system in

the state. Information technology offers the best prospects for improved surveillance and the state must use this to the full. For this, the legal framework needs to be changed and the government has to acquire certain powers as discussed earlier.

The state transport department will play the major role in piloting these changes. The department should have the guidance of a broad based committee under the chairmanship of the chief secretary. The committee should have representatives of the municipalities of Ahmedabad and Vadodara, the police department, oil companies, automobile manufacturers, NGOs, experts and GEC. The committee should be serviced by GEDA.

Research on automobile emission in Ahmedabad and Vadodara has been fragmentary. It is necessary to develop dispersion models to understand the contribution of automobile emissions to the ambient air quality. The feasibility of using CNG and LPG in the major cities have to be taken up early. The oil and gas companies may be encouraged to take these up.

Pollution from fly ash

Prescriptive policies have had little effect in promoting fly ash utilisation. Also, the marketing of fly ash as a cheap product has not succeeded. The approach should be reversed. Fly ash has to be marketed as a high value product. Regulations of the PWD prohibiting its use have to be reviewed.

The element of co-ordination between different agencies is important here. Further, it is necessary to keep track of new technologies of fly ash utilisation. Both these factors call for a standing machinery for monitoring and review. A state level task force under the chairmanship of Secretary, Energy with members from GEB, cement plants, industry, brick makers, architects, large construction companies, NGOs, leading citizens and GEC should be formed with this responsibility. This task force could be serviced by GEDA. The target should be to reach the 13% utilisation reached by the country within five years.

NTPC has developed the technique of dry disposal in high mounds which limits the wastage of land for fly ash disposal. The ash mounds can be planted over to stop wind erosion of fly ash. The feasibility of this method of disposal should be examined.

Research on fly ash utilisation has been going on at several places in the country. By contrast, little work is available on the pollution effects of fly ash. Work on contamination of water bodies, especially groundwater by leaching should be commissioned.

Renewables for power

The immediate task is to build a constituency for renewables by working out concrete numbers for the benefits of distributed generation. Although the idea is widely accepted in principle, only numbers can convince the ERC. Once a consensus is reached, it should be possible to set up 50 MW of additional capacity every year.

The separation of generation, transmission and distribution of electricity will prove to be a key action in this respect. In view of the possible privatisation of power generation, it is necessary for the government to have legal powers to issue directions for installation of capacity based on renewables, as proposed in the new Electricity Bill now pending in the Parliament.

GEDA should continue research on reducing the cost of power generation. Solar power (as opposed to solar PV) at the 50-500 KW range could be cost effective for Gujarat. This area needs attention. GEDA should also support studies on full-cycle costs of conventional power based on coal/lignite or gas.

The action plan is summarised in the Tables at Annexure I.

Cost of the action plan

The cost of implementing the plan will consist mainly of administrative costs of strengthening GEDA and of regular seminars and campaigns for wide dissemination of programs. The second component would be training and research and development.

The third component would comprise subsidies and interest subsidies on domestic fuels and technologies. The annual outlay till 2010 could be as below:

- Electrification of households - 25 crores
- Interest subsidy on LPG connections - 1 crore
- Improved chulahs - 10 crores
- Solar cookers - 2 crores
- Solar lanterns - 3 crores
- Biogas plants - 5 crores

The total outlay would be around 50 crores annually. The resources required for these programs could be raised by reallocation. The state government pays out Rs 1700 crores annually to the GEB to meet their deficit. It should be possible to save Rs 100 crores or more annually by tariff rationalisation and reductions in T&D losses. The savings could be allocated to GEDA.

sustainable energy development program

We have suggested a central role for GEDA in all of the above. GEDA will be able to play this role only so long as it remains in touch with NGOs, research institutions and energy experts and also enjoys the support of the state government. To this end, it is necessary that GEDA's work be guided by a state level steering committee chaired by the Energy Minister with experts in energy, transport, urban planning, industry leaders, NGOs, panchayats, women's organisations, universities and research institutes and related government departments as members.

The United Nations has recently argued in support of an international initiative on sustainable development of energy. The elements of this program are:

- Energy security
- Energy efficiency
- Renewable energy
- Access to energy sources
- Energy and transportation, etc.

Many of these are identical with the elements identified in this report. GEDA may bring together its activities under the umbrella of '**The Gujarat Sustainable Energy Development Program**'. This may help in forming a partnership with the UN and in getting resources and research inputs. It would establish sustainable development as the criteria to judge energy sector programs and help in getting a larger number of NGOs in the state interested in energy issues.

Annexure I - Action plans

PROBLEM: INDOOR AIR POLLUTION

All policy actions are executive in nature;

Some essential legal actions are in red;

All actions are short-term in nature

Mid-term actions are in blue; and

Long-term actions are in pink

Solution: Increased use of LPG, Biogas, Electricity, Solar cookers/lanterns		
	Action	Responsible agency
Policies	<ul style="list-style-type: none"> Review income generation programs to increase benefits to women beneficiaries Continue phasing out subsidy on kerosene and LPG Support expansion in domestic electricity supply Support soft loans for LPG connections Announce subsidy for LPG connections for the poorest consumers Promote private fuelwood plantation 	Central government, State Government Central Government ERC, State Government State Government State Government State Government
Institution development/ capacity building	<ul style="list-style-type: none"> Strengthen GEDA to act as the focal point of all energy related programs Promote ESCOs in partnership with banks, IRMA, IIM, energy companies 	State Government State Government, GEDA
Physical/technological	Step up coverage under improved chulahs, biogas, LPG etc. to cover sizable proportion of population by 2010	GEDA, ESCOs
Research/ studies	<ul style="list-style-type: none"> Support research into models on choice of domestic fuels Support design improvements of solar cookers Support studies on health impacts, medical costs of indoor pollution Organise seminars for experience sharing with other states 	GEDA GEDA, NID GEDA, NIOH GEDA
Awareness/communication	<ul style="list-style-type: none"> Organise campaigns for awareness of: <ul style="list-style-type: none"> health impacts of indoor pollution cleaner fuels and technologies importance of proper ventilation 	GEDA, GEC

PROBLEM: AUTOMOBILE EMISSIONS**Solution: Less emissions per kilometre from both new and 'in use' vehicles**

	Action	Responsible agency
Policies	<ul style="list-style-type: none"> Finalise auto fuel policy Phase out subsidy on kerosene to reduce adulteration of gasoline, diesel Amend Motor Vehicles Act and Rules to overhaul systems of vehicle inspection Notify revised PUC norms Revise road-tax rates and passenger fares to raise resources for better inspection, better maintenance and renewal of bus fleet 	Central Government Central Government Central Government/State Govt. Central Government State Government
Institution development/ capacity building	Form a monitoring Committee headed by Chief Secretary to generate public support for mitigation strategies and to maintain pressure for improvement	State Government
Physical/technological	Design and put in place a revised inspection system in partnership with auto manufacturers using information technology for better surveillance	State Government
Research/ studies	<ul style="list-style-type: none"> Support studies for developing dispersion models for Ahmedabad and Vadodara Motivate oil and gas companies to take up feasibility studies for CNG and LPG in Ahmedabad and Vadodara 	GEDA GEDA
Awareness/communication	<ul style="list-style-type: none"> Support initiatives by traffic police, rotary clubs etc. in traffic management Involve PCRA in campaigns for conservation 	GEDA GEDA

PROBLEM: POLLUTION FROM FLY ASH

Solution: Reduced generation and greater utilisation of fly ash		
	Action	Responsible agency
Policies	<ul style="list-style-type: none"> ▪ Continue power tariff rationalisation to improve financial health of GEB ▪ Support efforts to import LNG/natural gas ▪ Promote competition in coal production of improve quality of coal ▪ Rationalise import duty on coal to promote import of low ash coal ▪ Review policies of PWD to increase use of fly ash in public works 	State Government, ERC Central Government, State government Central Government Central Government State Government
Institution development/ capacity building	Form Task Force headed by Secretary, Energy to iron out coordination problems, review progress and upgrade technology	State Government
Physical/technological	<ul style="list-style-type: none"> ▪ Arrange for dry dumping of fly ash ▪ Supply dry ash from power plants to user industries ▪ Arrange for grading of fly ash, if necessary 	GEB, AEC, GSECL
Research/ studies	Support studies on contamination of surface and groundwater by fly ash	GEDA
Awareness/communication	Support awareness campaigns by entrepreneurs making bricks, building blocks and aggregates	GEDA

PROBLEM : LOW UTILISATION OF RENEWABLES FOR POWER GENERATION

Solution: Increased use of wind power, biomass, small hydro and solar PV in power generation

Policies	Action	Responsible agency
	<ul style="list-style-type: none"> Continue and expedite the formation of separate companies for generation, transmission and distribution of electricity 	State Government
	<ul style="list-style-type: none"> Expedite the passage of the Electricity Bill 	Central Government
	<ul style="list-style-type: none"> Decide tariff for power from renewables with the approval of ERC 	State Government
Institution development/ capacity building	Strengthen GEDA both by allocating larger resources and by building linkages with universities/research institutes and NGOs	State Government
Physical/technological	Adopt a target of 50 MW annual additional capacity from renewables	State Government, GEDA
Research/ studies	<ul style="list-style-type: none"> Support research on distributed power and its possible benefits in Gujarat 	GEDA
	<ul style="list-style-type: none"> Support research on solar power for distributed generation 	GEDA
	<ul style="list-style-type: none"> Support studies on full-cycle costing of coal/gas based power in Gujarat 	GEDA
Awareness/communication	Build a network of NGOs which can provide a strong forum for advocacy on renewables and other energy related issues	GEDA, State Government

T. E. R. I. LIBRARY

Acc. No. GR8651

Clas TERI
Au SEAP, Guj.
Tit

Date Issued	Borrower's Name	Date Returned

ACCESSION NUMBER

THE ENERGY AND RESOURCES INSTITUTE LIBRARY

DURATION OF
LOAN

HABITAT PLACE
Lodhi Road, New Delhi-110 003

Not later than the last
date stamped above.

